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(54) **ABNORMALITY DETERMINATION APPARATUS AND ABNORMALITY DETERMINATION METHOD FOR COOLANT TEMPERATURE SENSOR, AND ENGINE COOLING SYSTEM**

ABWEICHUNGSBESTIMMUNGSVORRICHTUNG UND ABWEICHUNGSBESTIMMUNGSVERFAHREN FÜR EINEN KÜHLMITTELTEMPERATURSENSOR UND MOTORKÜHLSYSTEM

APPAREIL ET PROCÉDÉ DE DÉTERMINATION D'ANOMALIE D'UN CAPTEUR DE TEMPÉRATURE POUR LIQUIDE DE REFROIDISSEMENT, ET SYSTÈME DE REFROIDISSEMENT DE MOTEUR

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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The invention relates to a cooling system of an engine (internal combustion engine) and, more particularly, to a coolant temperature sensor abnormality determination apparatus and a coolant temperature sensor abnormality determination method that determine the presence or absence of abnormality of a coolant temperature sensor of the cooling system.

2. Description of Related Art

[0002] With regard to an engine mounted in a vehicle or the like, a coolant jacket as a coolant passageway is provided in the engine (a cylinder block or a cylinder head), and the entire engine is cooled (or warmed) by circulating a coolant via the coolant jacket by a coolant pump. In conjunction with such a cooling system, there exists a technology in which a changeover valve that restricts the circulation of the coolant between an engine coolant passageway and a heater system (heater passageway) is provided, and while the engine is cold, the changeover valve is closed to stop passage of the coolant within the engine (within the coolant jacket) (to perform an in-engine coolant stop) so that quick warm-up of the engine is accomplished (e.g., see Japanese Patent Application Publication No. 2009-150266 (JP-A-2009-150266)).

[0003] A cooling system that performs the aforementioned in-engine coolant stop is provided with, for example, an engine coolant temperature sensor that detects the outlet coolant temperature of the engine, and a heater-system coolant temperature sensor (e.g., a heater inlet coolant temperature sensor) that detects the coolant temperature in a heater system. As an abnormality detection method of detecting abnormality of the heater-system coolant temperature sensor, there exists a method in which it is determined that the heater-system coolant temperature sensor is abnormal in the case where after elapse of a certain period following the start of the engine, it is found that the detected coolant temperature value detected by the heater-system coolant temperature sensor has not risen by a predetermined value or more (e.g., see Japanese Patent Application Publication No. 10-073047 (JP-A-10-073047)). Incidentally, an example of the abnormality of the coolant temperature sensor is a stuck abnormality in which the sensor value is fixed to a certain value.

[0004] By the way, as for the cooling system that performs the aforementioned in-engine coolant stop, in the case where the foregoing abnormality detection method is applied to the abnormality determination regarding the heater-system coolant temperature sensor, if a heat source (e.g., an exhaust heat recovery device or the like) disposed in the heater system has a fault or the like, the temperature of the coolant in the heater system does not rise even after a certain period of time elapses following the start of the engine. Therefore, since the detected coolant temperature value provided by the heater-system coolant temperature does not rise, it sometimes happens that the heater-system coolant temperature sensor is falsely determined as being abnormal although the sensor is actually normal.

SUMMARY OF THE INVENTION

[0005] The invention provides a coolant temperature sensor abnormality determination apparatus and a coolant temperature sensor abnormality determination method that are capable of precisely determining whether a coolant temperature sensor that detects the temperature of a coolant in a heater system is abnormal without making a false determination, in a cooling system that stops passage of a coolant within an engine.

[0006] A coolant temperature sensor abnormality determination apparatus in accordance with a first aspect of the invention is a coolant temperature sensor abnormality determination apparatus which is applied to an engine cooling system (a cooling system that performs an in-engine coolant stop) that includes an engine coolant passageway, a bypass passageway (heater passageway) that bypasses an engine, a control valve (changeover valve) that restricts circulation of a coolant between the engine coolant passageway and the bypass passageway, and a bypass coolant temperature sensor (heater inlet coolant temperature sensor) that detects bypass coolant temperature in the bypass passageway, and which determines whether the bypass coolant temperature sensor is abnormal, and which includes determination means for opening the control valve if amount of increase of a detected value of the bypass coolant temperature obtained when the bypass coolant temperature is estimated to be equal to or greater than a predetermined value (concretely, for example, when the amount of intake air taken into the engine (the integrated intake air amount value following the time of the start of the engine) becomes equal to or greater than a predetermined value) is smaller than the predetermined value, and for determining that the bypass coolant temperature sensor is abnormal based on amount of change in the detected value of the bypass coolant temperature obtained after the control valve opens.

[0007] Besides, in the coolant temperature sensor abnormality determination apparatus in accordance with the foregoing aspect, the determination means may determine that the bypass coolant temperature sensor is normal, if the amount of increase in the detected value of the bypass coolant temperature becomes equal to or greater than the predetermined value after the control valve opens that the bypass coolant temperature sensor is normal, if the amount of increase in the detected value of the bypass coolant temperature becomes equal to or greater than the predetermined value after the control valve opens, and the determination means may determine that the bypass coolant temperature sensor is abnormal, if the amount of increase in the detected value of the bypass coolant temperature is smaller than the predetermined value after the control valve opens.

[0008] Besides, in the coolant temperature sensor abnormality determination apparatus in accordance with the foregoing aspect, the bypass passageway (heater passageway) may be provided with at least one of an exhaust heat recovery device and an EGR (Exhaust Gas Recirculation) cooler.

[0009] In the coolant temperature sensor abnormality determination apparatus in accordance with the foregoing aspect, firstly, in the case where the amount of increase of a detected bypass coolant temperature value obtained when the bypass coolant temperature is estimated to be equal to or greater than a predetermined value (when the amount of air taken into the engine (the integrated intake air amount value following the start of the engine) becomes equal to or greater than a predetermined value) (the deviation of the detected bypass coolant temperature value from the detected bypass coolant temperature value obtained when the engine is started) is greater than or equal to the predetermined value, the apparatus determines that the bypass coolant temperature sensor is normal. On the other hand, in the case where the foregoing amount of increase in the detected bypass coolant temperature value is smaller than the predetermined value, "abnormality of the bypass coolant temperature" or "a fault of a heat source of the bypass passageway" is conceivable, so that the apparatus opens the control valve that restricts the circulation of the coolant between the engine coolant passageway and the bypass passageway.

[0010] Because the control valve opens, the coolants from the two systems, that is, the engine coolant passageway and the bypass passageway, circulate through the two systems, and the high-temperature coolant warmed by the engine flows into the bypass passageway. This increases the temperature of the coolant in the bypass passageway even if the bypass passageway has no heat source available (even if a heat source, such as an exhaust heat recovery device, an EGR cooler, etc., has a fault), so that the detected bypass coolant temperature value detected by the coolant temperature sensor increases provided that the bypass coolant temperature sensor is normal. Therefore, in the foregoing aspect of the invention, utilizing these points, the apparatus determines that the bypass coolant temperature sensor is normal in the case where the amount of change in the detected bypass coolant temperature value after the control valve opens is greater than or equal to a predetermined value, and determines that the bypass coolant temperature sensor is abnormal (has a stuck abnormality) in the case where the amount of change in the detected bypass coolant temperature value is smaller than a predetermined value.

[0011] As described above, according to the coolant temperature sensor abnormality determination apparatus in accordance with the foregoing aspect, in the case where the amount of increase of the detected bypass coolant temperature value obtained when the bypass coolant temperature is estimated to be equal to or greater than a predetermined value (when the amount of air taken into the engine becomes equal to or greater than a predetermined value) is smaller than the predetermined value, the apparatus opens the control valve to allow the high-temperature coolant from the engine to flow into the bypass passageway so that the temperature of the coolant in the bypass passageway increases, and while such a state of increased coolant temperature is maintained, determination regarding the bypass coolant temperature sensor is performed on the basis of the amount of change in the detected bypass coolant temperature value detected by the bypass coolant temperature sensor. Therefore, even if the bypass passageway does not have a heat source available due to a fault of an exhaust heat recovery device, an EGR cooler, etc., the apparatus is able to precisely determine whether the bypass coolant temperature sensor is abnormal without making a false determination.

[0012] Besides, in the coolant temperature sensor abnormality determination apparatus in accordance with the foregoing aspect, the control valve that restricts the circulation of the coolant between the engine coolant passageway and the bypass passageway may be a temperature-sensitive operation valve that has a temperature sensitive portion that displaces a valve body, and the coolant temperature sensor abnormality determination apparatus may determine that the control valve has opened, when an estimated value of ambient coolant temperature of the control valve becomes equal to or greater than a valve-opening temperature of the control valve. Adoption of this construction makes it possible to shorten the time that is needed for determination whether the control valve has opened. This will be explained below.

[0013] Firstly, a cooling system (a cooling system that performs an in-engine coolant stop) to which the coolant temperature sensor abnormality determination apparatus in accordance with the foregoing aspect uses, for example, a temperature-sensitive operation valve that has a temperature sensitive portion that displaces a valve body, as a control valve provided at a coolant outlet of the engine. In this case, an electric heater is buried in the temperature sensitive portion so that the control valve can also be forced to open by melting the thermo-wax through the use of heat produced by electrifying the electric heater (i.e. to open by electrification of the heater). The valve is opened by electrifying the heater when the foregoing amount of increase in the detected bypass coolant temperature value is smaller than the predetermined value. An example of the method of determining whether the control valve has opened is a method of determining whether the valve has opened by using the elapsed time following the start of electrification of the electric heater.

[0014] In the case where it is determined that the control valve has opened on the basis of the duration of electrification of the heater, in order to prevent a false determination that the control valve has opened when the valve actually has not opened, an open-valve state criterion value is adapted on the basis of the condition in which it takes the longest time before the control valve is opened. However, as for such an adaptation, the margin is very large, so that there is inevitably a long time before the determination regarding the normality or abnormality of the bypass coolant temperature sensor is performed. However, by adopting a method in which it is determined that the control valve has opened when the estimated value of the ambient coolant temperature of the control valve becomes equal to or greater than the valve-opening temperature, it becomes possible to determine that the control valve has opened according to the actual open state of the valve. Since this eliminates the need to provide the aforementioned margin, only a short time is needed before it is determined that the valve has opened, so that the time prior to the determination regarding the normality or abnormality of the bypass coolant temperature sensor can be shortened.

[0015] It is to be noted herein that in the coolant temperature sensor abnormality determination apparatus in accordance with the foregoing aspect, if the determination regarding the bypass coolant temperature sensor is performed during a state in which the high-temperature coolant in the engine coolant passageway and the coolant in the bypass passageway are not sufficiently mixed together (a state in which the temperature of the coolant in the bypass passageway has not sufficiently increased) after the control valve has opened, there is a possibility of making a false determination that the sensor is abnormal when the sensor is actually normal. Hence, in the coolant temperature sensor abnormality determination apparatus in accordance with the foregoing aspect, in order to prevent the false abnormality determination, the determination regarding the bypass coolant temperature sensor may be executed after elapse of a predetermined time following the opening of the control valve, that is, after elapse of a time that is needed for the coolant temperature in the bypass passageway to sufficiently increase.

[0016] According to the coolant temperature sensor abnormality determination apparatus in accordance with the foregoing aspect, if the amount of increase in the detected bypass coolant temperature value obtained when the bypass coolant temperature is estimated to be equal to or greater than a predetermined value is relatively small, the control valve is opened to increase the coolant temperature in the bypass passageway, and then the determination regarding abnormality of the coolant temperature sensor is performed on the basis of the amount of change in the detected bypass coolant temperature value after the control valve has opened. Therefore, the presence of abnormality of the bypass coolant temperature sensor can be precisely determined without making a false determination.

[0017] A coolant temperature sensor abnormality determination method in accordance with a second aspect of the invention is a coolant temperature sensor abnormality determination method which is for use in an engine cooling system that includes an engine coolant passageway, a bypass passageway that bypasses an engine, a control valve that restricts circulation of a coolant between the engine coolant passageway and the bypass passageway, and a bypass coolant temperature sensor that detects bypass coolant temperature in the bypass passageway, and which determines whether the bypass coolant temperature sensor is abnormal, and the method includes: detecting the bypass coolant temperature by using the bypass coolant temperature sensor when the bypass coolant temperature is estimated to be equal to or greater than a predetermined value, determining that the bypass coolant temperature sensor is normal if amount of increase in the bypass coolant temperature detected is greater than or equal to the predetermined value; and opening the control valve if the amount of increase in the bypass coolant temperature detected is smaller than the predetermined value, and detecting the bypass coolant temperature again by using the bypass coolant temperature sensor after the control valve opens, and determining whether the bypass coolant temperature sensor is abnormal on the basis of the amount of change in the bypass coolant temperature between before and after the control valve opens.

[0018] An engine cooling system in accordance with a third aspect of the invention includes: an engine coolant passageway; a bypass passageway that bypasses an engine; a control valve that restricts circulation of a coolant between the engine coolant passageway and the bypass passageway; a bypass coolant temperature sensor that detects bypass coolant temperature in the bypass passageway; and a coolant temperature sensor abnormality determination portion that opens the control valve if amount of increase of a detected value of the bypass coolant temperature obtained when the bypass coolant temperature is estimated to be equal to or greater than a predetermined value is smaller than the predetermined value, and that determines whether the bypass coolant temperature sensor is abnormal based on amount of change in the detected value of the bypass coolant temperature obtained after the control valve opens.

[0019] According to the coolant temperature sensor abnormality determination method in accordance with the second aspect and the engine cooling system in accordance with the third aspect, it is possible to achieve substantially the same effects as those achieved by the coolant temperature sensor abnormality determination apparatus in accordance with the first aspect.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] Features, advantages, and technical and industrial significance of exemplary embodiments of the invention will be described below with reference to the accompanying drawings, in which like numerals denote like elements, and wherein:

FIG. 1 is a general construction diagram showing an example of a cooling system of an engine to which an embodiment of the invention is applied;
FIG. 2A is a sectional view showing a structure of a changeover valve for use in the cooling system shown in FIG. 1, and showing a closed valve state of the changeover valve;
FIG. 2B is a sectional view showing a structure of the changeover valve for use in the cooling system shown in FIG. 1, and showing an open valve state of the changeover valve;
FIG. 3A is a diagram showing the flow of the coolant circulating in a coolant passageway during a cold state of the engine in the cooling system of the engine shown in FIG. 1;
FIG. 3B is a diagram showing the flow of the coolant circulating in the coolant passageway during a semi-warmed-up state of the engine in the cooling system of the engine shown in FIG. 1;
FIG. 4 is a diagram showing the flow of the coolant circulating in the coolant passageway during a completely warmed-up state of the engine in the cooling system of the engine shown in FIG. 1;
FIG. 5 is a flowchart showing an example of a coolant temperature sensor abnormality determination process that an ECU executes in the embodiment of the invention; and
FIG. 6 is a timing chart showing an example of the coolant temperature sensor abnormality determination process in the embodiment of the invention

DETAILED DESCRIPTION OF EMBODIMENTS

[0021] Hereinafter, embodiments of the invention will be described with reference to the drawings.

[0022] A cooling system of an engine 1 (an in-engine coolant stop cooling system) will be described with reference to FIG. 1.

[0023] The cooling system of this embodiment includes an electric coolant pump 2, a radiator 3, a thermostat 4, a heater 5, an exhaust heat recovery device 6, an EGR (Exhaust Gas Recirculation) cooler 7, a changeover valve 10, a coolant passageway 200 for circulating a coolant to these appliances, etc.

[0024] The coolant passageway 200 includes an engine coolant passageway 201 that circulates the coolant (e.g., LLC (Long Life Coolant)) via the engine 1, the radiator 3 and the thermostat 4, and a heater passageway 202 that circulates the coolant via the EGR cooler 7, the exhaust heat recovery device 6, the heater 5 and the thermostat 4. In this embodiment, for both the circulation of the coolant through the engine coolant passageway 201 and the circulation of the coolant through the heater passageway 202, one electric coolant pump (electric water pump) 2 is employed.

[0025] The engine 1 is a gasoline engine, a diesel engine, etc., that is mounted in a conventional vehicle, a hybrid vehicle, etc., and a cylinder block and a cylinder head of the engine are provided with a coolant jacket (not shown). The engine 1 is provided with an engine coolant temperature sensor 21 that detects the coolant temperature at a coolant outlet (a coolant jacket outlet of the cylinder head) 1b. Besides, in an intake passageway of the engine 1, there are disposed an intake air temperature sensor 23 that detects the temperature of intake air, and an air flow meter 24 that detects the amount of air taken into the engine 1. Output signals of the engine coolant temperature sensor 21, the intake air temperature sensor 23 and the air flow meter 24 are input to an ECU (Electronic Control Unit) 300.

[0026] The electric coolant pump 2 is a coolant pump whose discharge flow amount (discharge pressure) can be variably set by controlling the rotation speed of an electric motor. The electric coolant pump 2 is disposed so that a discharge port thereof communicates with a coolant inlet 1a of the engine 1 (an inlet of the coolant jacket). The operation of the electric coolant pump 2 is controlled by the ECU 300. Besides, the electric coolant pump 2 is driven along with the starting of the engine 1, and the discharge flow amount thereof is controlled according to the operation state of the engine 1, and the like.

[0027] The thermostat 4 is a valve device that operates by, for example, expansion and contraction of a thermo-wax of a temperature sensitive portion, and is designed so that when the coolant temperature is relatively low, the coolant passageway between the radiator 3 and the electric coolant pump 2 is shut down so as to keep the coolant from flowing into the radiator 3 (the engine coolant passageway 201). On the other hand, when the warm-up of the engine 1 has been completed, that is, when the coolant temperature is relatively high, the thermostat 4 operates (opens its valve) according to the coolant temperature so as to allow a part of the coolant to flow into the radiator 3, so that heat recovered by the coolant is released from the radiator 3 into the atmosphere. Incidentally, in this embodiment, the thermostat 4 has been set so as to open when the ambient coolant temperature of the temperature sensitive portion (≈the wax temperature) reaches a coolant temperature (e.g., 82°C or higher) that is higher than the valve opening temperature of the changeover valve 10 (e.g., 70°C) described later.

[0028] The heater passageway 202 is a bypass passageway that bypasses the engine 1. The EGR cooler 7, the exhaust heat recovery device 6 and the heater 5 are connected in series on the heater passageway 202, in that order from the upstream side in terms of the flow of the coolant. The coolant discharged from the electric coolant pump 2 circulates in the order of "the EGR cooler 7→the exhaust heat recovery device 6→the heater 5→the thermostat 4→the electric coolant pump 2". A heater connection passageway 202a is connected to the heater passageway 202 between the EGR cooler 7 and the exhaust heat recovery device 6. The heater connection passageway 202a is connected, via the changeover valve 10, to a coolant outlet 1b of the engine 1 (a coolant jacket outlet of the cylinder head). The changeover valve (control valve) 10 opens and closes the heater connection passageway 202a. Details of the changeover valve 10 will be described later.

[0029] The heater 5 is a heat exchanger for heating a cabin of the vehicle by utilizing heat of the coolant, and is disposed facing a blow duct of the air-conditioner. Specifically, a design is made such that when the cabin is heated (when the heater is on), the air-conditioned air that flows in the blow duct is passed through the heater 5 (a heater core) and the obtained warmed air is supplied into the cabin, and such that in the other times (e.g., during the cooling) (when the heater is off), the air-conditioned air bypasses the heater 5. On the heater 5, there is disposed a heater inlet coolant temperature sensor 22. An output signal of the heater inlet coolant temperature sensor 22 is input to the ECU 300. Incidentally, since the inlet coolant temperature of the heater 5 is equivalent to the temperature of the coolant that flows in the heater passageway 202 (bypass passageway), the heater inlet coolant temperature sensor 22 corresponds to a bypass coolant temperature sensor.

[0030] The exhaust heat recovery device 6 is a heat exchanger that is disposed on an exhaust passageway of the engine 1 for the purpose of recovering heat from the exhaust gas by using the coolant. The heat recovered by the exhaust heat recovery device 6 is utilized for the warm-up of the engine and the heating of the cabin. The EGR cooler 7 is a heat exchanger that is disposed on an EGR passageway that returns a part of the exhaust gas that flows in the exhaust passageway of the engine 1 to an intake passageway for the purpose of cooling the EGR gas that passes (refluxes) in the EGR passageway.

[0031] Next, the changeover valve 10 for use in the cooling system will be described with reference to FIGS. 2A and 2B.

[0032] The changeover valve 10 in this embodiment includes a housing 11, a valve body 12, a compression coil spring 13, a temperature sensitive portion 14, etc.

[0033] The housing 11 is provided with a coolant inlet 11a that is connected to the coolant outlet (the coolant jacket opening of the cylinder head) 1b of the engine 1 shown in FIG. 1, a radiator connection opening 11b that is connected to the radiator 3, and a heater connection opening 11c. The heater connection opening 11c is connected to the heater passageway 202 via the heater connection passageway 202a shown in FIG. 1.

[0034] Inside the housing 11, a valve seat 111 and a spring seat 112 are provided, facing each other. A space between the valve seat 111 and the spring seat 112 (a space on an upstream side of the valve body 12) forms a coolant lead-in portion 11d. The coolant inlet 11a communicates with the coolant lead-in portion 11d. Via the coolant lead-in portion 11d, the radiator connection opening 11b communicates with the coolant inlet 11 a. Besides, a space on a downstream side of the valve body 12 forms a coolant lead-out portion 11e with which the heater connection opening 11c communicates.

[0035] The valve body 12 is disposed between the valve seat 111 and the spring seat 112 inside the housing 11 so as to be able to contact the valve seat 111 and separate therefrom. This valve body 12 and a case 141 of the temperature sensitive portion 14 (described later) are integrated together. Besides, the compression coil spring 13 is placed between the valve body 12 and the spring seat 112. Due to the elastic force of the compression coil spring 13, the valve body 12 is urged toward the valve seat 111.

[0036] The temperature sensitive portion (temperature sensitive actuator) 14 includes a case 141 and a rod 142. The rod 142 is a rod-shape member extending in the opening-closing direction of the valve body 12, and disposed freely slidably relative to the case 141. The rod 142 penetrates the valve body 12. The valve body 12 is slidable in the opening-closing direction relative to the rod 142. Besides, a distal end portion of the rod 142 penetrates a wall body 11f of the housing 11 (a wall body at the opposite side to the coolant inlet 11a), and the distal end portion is retained by a rod retainer member 16.

[0037] An interior of the case 141 of the temperature sensitive portion 14 is filled with a thermo-wax 143 that expands and contracts due to changes in the ambient coolant temperature of the temperature sensitive portion 14 (hereinafter, also referred to as changeover valve's ambient coolant temperature) (i.e., changes in the wax temperature). The expansion and contraction of the thermo-wax 143 changes the amount of protrusion of the rod 142 relative to the case 141. Incidentally, the thermo-wax 143 is housed within a seal member 144 that is made of rubber or the like.

[0038] In the changeover valve 10 having a structure as described above, when the changeover valve's ambient coolant temperature (≈the wax temperature) Tvw is lower than a predetermined value (70°C in this embodiment), there occurs a state in which the amount of protrusion of the rod 142 from the case 141 is small (i.e., the amount of immersion of the rod 142 in the case 141 is large) so that the valve body 12 is seated on the valve seat 111 (i.e., is closed) by the elastic force of the compression coil spring 13 (FIG. 2A). When, from this closed valve state, the changeover valve's ambient coolant temperature Tvw becomes equal to or higher than the predetermined value (equal to or higher than 70°C), the thermo-wax 143 of the temperature sensitive portion 14 expands. Due to the expansion of the thermo-wax

143, the amount of protrusion of the rod 142 from the case 141 increases, the entire temperature sensitive portion 14, that is, the valve body 12, moves in a direction away from the valve seat 111, overcoming the elastic force of the compression coil spring 13, so that the valve body 12 separates from the valve seat 111 (opens) (FIG. 2B).

[0039] Thus, when the changeover valve's ambient coolant temperature Tvw is lower than the predetermined value (70°C), the changeover valve 10 in this embodiment assumes a closed state, in which the coolant outlet 1b of the engine 1 (the engine coolant passageway 201) shown in FIG. 1 and the heater passageway 202 shown in FIG. 1 are shut off from each other (the circulation of the coolant between the engine coolant passageway and the bypass passageway is restricted). On the other hand, when the changeover valve's ambient coolant temperature Tvw is greater than or equal to the predetermined value (greater than or equal to 70°C), the changeover valve 10 assumes an open valve state, in which the coolant outlet 1b of the engine 1 (the engine coolant passageway 201) and the heater passageway 202 shown in FIG. 1 communicate with each other. Incidentally, when the thermostat 4 shown in FIG. 1 is in the closed valve state although the coolant inlet 11a and the radiator connection opening 11b communicate with each other, the coolant having flown into the coolant inlet 11a does not flow into the radiator connection opening 11b.

[0040] It is to be noted herein that in the changeover valve 10 in this embodiment, an electric heater 15 is buried within the temperature sensitive portion 14. By electrifying the electric heater 15 so that heat generated by the electric heater 15 melts the thermo-wax 143, the changeover valve 10 can be forced to assume the open state. The opening of the changeover valve 10 due to the heater electrification is performed during a coolant temperature sensor abnormality determination process described later (at the time of the second determination regarding normality of the heater inlet coolant temperature 22), or the like. Incidentally, the electric heater 15 of the changeover valve 10 is operated by a changeover valve controller (not shown). The changeover valve controller performs electrification of the electric heater 15 of the changeover valve 10 according to a valve opening request from the ECU 300.

[0041] The flow of the coolant circulating through the coolant passageway of the cooling system of the engine 1 shown in FIG. 1 will be described with reference to FIG. 3 and FIG. 4.

[0042] Firstly, during the cold state of the engine, since the ambient coolant temperature Tvw of the temperature sensitive portion 14 of the changeover valve 10 is low (less than 70°C), the changeover valve 10 assumes the closed state, so that the passage of the coolant within the engine 1 (within the coolant jacket) is stopped (in-engine coolant stop). Due to this, the engine 1 is quickly warmed up. Besides, when the changeover valve 10 is in the closed state, the coolant circulates through the heater passageway 202 as shown in FIG. 3A due to operation of the electric coolant pump 2, and the coolant flows in the sequence of "the electric coolant pump 2→the EGR cooler 7→the exhaust heat recovery device 6→the heater 5→the thermostat 4→the electric coolant pump 2". If there is a cabin-heating request during the quick warm-up as described above, it suffices that the amount of heat needed for the heater 5 is covered by the heat that is recovered by the exhaust heat recovery device 6.

[0043] Next, when the engine 1 becomes semi-warmed up and the ambient coolant temperature Tvw of the temperature sensitive portion 14 of the changeover valve 10 becomes equal to or higher than the predetermined value (equal to or higher than 70°C), the changeover valve 10 opens. When the changeover valve 10 is open, the coolant flows in the sequence of "the electric coolant pump 2→the coolant inlet 1a of the engine 1→the inside of the engine 1 (within the coolant jacket) →the coolant outlet 1b of the engine 1→the changeover valve 10→the heater connection passageway 202a", in addition to the circulation of the coolant in the heater passageway 202, as shown in FIG. 3B, so that the engine 1 is cooled. Besides, when the changeover valve 10 assumes the open state, the coolant in the engine coolant passageway 201 (in the engine 1) and the coolant in the heater passageway (bypass passageway) 202 are mixed.

[0044] Then, when the engine 1 reaches a completely warmed-up state, the thermostat 4 operates (opens its valve) so that a portion of the coolant flows into the radiator 3, as shown in FIG. 4, and therefore heat recovered by the coolant is released from the radiator 3 into the atmosphere.

[0045] Next, the ECU 300 will be described. The ECU 300 includes a CPU, a ROM, a RAM, a back-up RAM, etc. The ROM stores various control programs, maps that are referred to at the time of execution of the various control programs, etc. The CPU executes computation processes on the basis of the various control programs or maps stored in the ROM. Besides, the RAM is a memory for temporarily storing results of computations by the CPU, data input from various sensors, etc. The back-up RAM is a non-volatile memory for storing data or the like that needs to be stored, when the engine 1 is stopped.

[0046] The ECU 300 is connected to various sensors that detect states of operation of the engine 1, including the engine coolant temperature sensor 21, the intake air temperature sensor 23 and the air flow meter 24, as shown in FIG. 1. Besides, the ECU 300 is also connected to the heater inlet coolant temperature sensor 22, an ignition switch (not shown), etc.

[0047] The ECU 300, on the basis of output signals from various sensors that detect the states of operation of the engine, executes various controls of the engine 1 that include an opening degree control of a throttle valve of the engine 1, a fuel injection amount control (an opening/closing control of injectors), etc. Besides, the ECU 300 also executes a "coolant temperature sensor abnormality determination process" described below.

(EXAMPLE 1 OF DETERMINATION PROCESS)

[0048] An example of the abnormality determination process for the heater inlet coolant temperature sensor 22 will be described with reference to a flowchart shown in FIG. 5. The process routine shown in FIG. 5 is executed by the ECU 300.

[0049] The process routine shown in FIG. 5 is started at the time point (IG-ON) when the ignition switch is turned on. When the process routine shown in FIG. 5 is started, the ECU 300, firstly in step ST101, picks the heater inlet coolant temperature thw2 occurring at the time of start of the engine from the output signal of the heater inlet coolant temperature sensor 22. Next, in step ST102, the ECU 300 reads in an abnormality determination value α (°C) for use in the determination processes of step ST105 and step ST110 that are described later. This abnormality determination value α may be a constant value (e.g., α=5°C), or may also be variably set according to the coolant temperature occurring at the time of start of the engine, with reference to a map or the like. Incidentally, the abnormality determination value α (constant value) or a map for calculating the abnormality determination value α is stored in the ROM of the ECU 300.

[0050] In step ST103, ECU 300 calculates an integrated value (Σga) of the amount of intake air from the time of start of the engine, on the basis of the output signal of the air flow meter 24. In step ST104, the ECU 300 determines whether the integrated intake air amount value (Σga) is greater than or equal to a prescribed value β [g]. At the time point when the result of the determination is found to be an affirmative determination (YES) (the time point when the state of $\Sigma ga \geq \beta$ [g] is reached), the ECU 300 determines that a pre-determination condition is satisfied, and then proceeds to step ST105.

[0051] Incidentally, as for the prescribed value β [g], through experiments, simulation, etc., an integrated value (Σga) of the amount of intake air is acquired beforehand which is needed for the amount of change (deviation) in the detected coolant temperature value provided by the heater inlet coolant temperature sensor 22 (in the normal state) from the time of start of the engine to become equal to or greater than a predetermined value (the abnormality determination value α=5 or more [°C]) in the process in which the coolant temperature in the heater passageway 202 increases due to the heat quantity that transfers to the coolant circulating in the heater passageway 202 from the heat of the exhaust gas by the exhaust heat recovery device 6, the EGR cooler 7, etc., and the prescribed value β [g] is adapted on the basis of the result of the acquisition, and then is stored into the ROM of the ECU 300.

[0052] In step ST105, the ECU 300 calculates a deviation of the heater inlet coolant temperature thw2 (detected value) (i.e., a deviation thereof (thw2 deviation) from the detected heater inlet coolant temperature value obtained at the time of start of the engine)) on the basis of the output signal of the heater inlet coolant temperature sensor 22 obtained when the integrated intake air amount value (Σga) becomes equal to or greater than the prescribed value β [g], and then determines whether the thw2 deviation is greater than or equal to the abnormality determination value α [°C] read in in step ST102 (the first normality determination to be made). If the result of the determination is an affirmative determination (YES) (if thw2 deviation$\geq\alpha$), the ECU 300 determines that the heater inlet coolant temperature sensor 22 is normal (step ST 111). If the result of the determination in step ST105 is a negative determination (NO) (if thw2 deviation$<\alpha$), the ECU 300 proceeds to step ST106.

[0053] It is to be noted herein that if the result of the determination in step ST105 is a negative determination (NO), the ECU 300 cannot determine whether there exists a situation in which "the heater inlet coolant temperature sensor 22 is abnormal" or a situation in which "the exhaust heat recovery device 6 or the EGR cooler 7 has a fault". Therefore, in this example, after the changeover valve 10 is forced to be opened, the second normality determination regarding the heater inlet coolant temperature sensor 22 is performed, as described later.

[0054] In step ST106, the ECU 300 starts electrification of the electric heater 15 of the changeover valve 10 by outputting a valve opening request to the changeover valve controller. Incidentally, the ECU 300 counts the elapsed time from the time point of starting electrification of the electric heater 15 of the changeover valve 10.

[0055] Next in step ST107, the ECU 300 determines whether "the changeover valve is free of a closed-state fault". If the result of the determination is an affirmative determination (YES), the ECU 300 proceeds to step ST108. If the result of the determination in step ST107 is a negative determination (NO), the ECU 300 does not perform the determination regarding the normality or abnormality of the heater inlet coolant temperature sensor 22 (step ST113, in which the determination is skipped). Incidentally, the term "closed-state fault" herein refers to a fault in which the valve is in a closed state and is not able to be opened.

[0056] An example of the determination process of step ST107 will be concretely described. In the case where the changeover valve 10 has the closed-state fault, the coolant in the engine 1 remains still even if the heater 15 is electrified, and therefore the amount of increase in the engine coolant temperature thw1 detected by the engine coolant temperature sensor 21 is large. On the other hand, in the case where the changeover valve 10 is normal (the case where low-temperature coolant flows into the engine 1), the amount of increase in the engine coolant temperature thw 1 (detected value) is relatively small (or the detected coolant temperature value thw1 declines). Utilizing this point, if the amount of increase in the engine coolant temperature thw1 detected by the engine coolant temperature sensor 21 after the heater 15 is electrified is smaller than a predetermined value, the ECU 300 determines that "the changeover valve is free of the closed-state fault", and proceeds to step ST108. Incidentally, in the case where it is necessary to obtain a determination that the engine coolant temperature sensor 21 is normal, the ECU 300, for example, calculates a difference [thw1-tha] between the engine coolant temperature thw1 (detected value) and the intake air temperature tha (detected value), and determines whether the temperature difference [thw1-tha] is within a predetermined range (e.g., $-20°C \leq thw1-tha \leq 20°C$), and determines that the engine coolant temperature sensor 21 is normal if the result of the determination is an affirmative determination (YES).

[0057] Incidentally, in the case where the changeover valve 10 is equipped with a sensor that detects the amount of valve lift, the presence or absence of the "closed-state fault of the changeover valve" may be determined on the basis of a detected value provided by the valve lift sensor.

[0058] In step ST108, the ECU 300 determines whether a coolant mixture criterion time has elapsed following the time point of starting the electrification of the electric heater 15 of the changeover valve 10. The "coolant mixture criterion time" for use in the process of step ST108 is adapted on the basis of the amount of time from the start of the electrification of the electric heater 15 to the actual opening of the changeover valve 10 and the amount of time from the opening of the changeover valve 10 to when the coolant in the engine coolant passageway 201 (in the engine 1) and the coolant in the heater passageway 202 sufficiently mix (to when the temperature of the coolant in the heater passageway 202 sufficiently rises).

[0059] Concretely, on the basis of a condition in which it takes the longest time from when the electric heater 15 of the changeover valve 10 starts to be electrified to when the changeover valve 10 is opened (e.g., a condition in which the idling operation is being performed and the engine is in a low-temperature environment), the time time1 (see FIG. 6) needed for opening the changeover valve 10 is adapted by experiments, simulation, etc. Besides, as for the time time2 needed for sufficient mixture of the coolant in the engine coolant passageway 201 (in the engine 1) and the coolant in the heater passageway 202 (see FIG. 6), the time time2 is inversely proportional to the amount of flow of the coolant in the engine 1 occurring after the changeover valve 10 is opened, and therefore this point is taken into account in adapting the time time2 on the basis of experiments, simulations, etc. A "value [timel+time2]" obtained by summing the adapted "time time1 needed for opening the valve" and the adapted "time time2 needed for mixing the coolant" is set as a "coolant mixture criterion time" for use in the determination process of step ST107.

[0060] Then, at the time point when the elapsed time following the start of the electrification of the electric heater 15 reaches the aforementioned coolant mixture criterion time (the time point when the result of the determination in step ST108 is found to be an affirmative determination (YES)), the ECU 300 discontinues the changeover valve-opening request, and stops the electrification of the electric heater 15 of the changeover valve 10 (step ST109), and then proceeds to step ST110.

[0061] In step ST110, the ECU 300 calculates a deviation of the heater inlet coolant temperature thw2 (detected value) (i.e., a deviation thereof (thw2 deviation) from the detected heater inlet coolant temperature value obtained when the changeover valve is opened (when the engine is started)) on the basis of the output signal of the heater inlet coolant temperature sensor 22, and then determines whether the thw2 deviation is greater than or equal to the abnormality determination value α [°C] read in in step ST102 (the second normality determination). If the result of the determination is an affirmative determination (YES) (if thw2 deviation$\geq\alpha$), the ECU 300 determines that the heater inlet coolant temperature sensor 22 is normal (step ST111). If the result of the determination in step ST110 is a negative determination (NO) (if thw2 deviation$<\alpha$), the ECU 300 determines that the heater inlet coolant temperature sensor 22 has the stuck abnormality (step ST112).

[0062] Next, a concrete example of the abnormality determination process regarding the heater inlet coolant temperature sensor 22 will be described with reference to FIG. 6. Incidentally, FIG. 6 shows an example of changes in the heater inlet coolant temperature thw2 (detected value) in the case where the heater inlet coolant temperature sensor 22 is normal and where the bypass passageway has no heat source available due to faults of the exhaust heat recovery device 6 and the EGR cooler 7.

[0063] Firstly, in the case where the deviation of the heater inlet coolant temperature thw2 (detected value) obtained when the integrated intake air amount value ($\sum$ga) from the start of the engine becomes greater than or equal to the prescribed value β [g] (the first normality determination) is greater than or equal to the abnormality determination value α [°C], the ECU 300 determines that the heater inlet coolant temperature sensor 22 is normal. On the other hand, in the case where the deviation of the heater inlet coolant temperature thw2 (detected value) obtained when the integrated intake air amount value ($\sum$ga) becomes greater than or equal to the prescribed value β [g] (the first normality determination) is smaller than the abnormality determination value α [°C] (the case where the ECU 300 cannot determine whether there exists a situation in which "the heater inlet coolant temperature sensor 22 is abnormal" or a situation in which "the exhaust heat recovery device 6 or the EGR cooler 7 has a fault"), the ECU 300 starts electrification of the electric heater 15 of the changeover valve 10, as shown in FIG. 6.

[0064] After the changeover valve 10 is actually opened by electrification of the electric heater, the high-temperature coolant from the engine 1 flows into the heater passageway 202 and therefore the coolant temperature in the heater passageway 202 increases even if the exhaust heat recovery device 6 and/or the EGR cooler 7 has a fault. Then, when there is reached a state in which the coolant in the engine coolant passageway 201 (in the engine 1) and the coolant in the heater passageway 202 are sufficiently mixed, the temperature of the coolant in the heater passageway 202 becomes sufficiently high. At this time, if the heater inlet coolant temperature sensor 22 is normal, the amount of change in the heater inlet coolant temperature thw2 (detected value) detected by this coolant temperature sensor 22 becomes large, so that the deviation of the heater inlet coolant temperature thw2 becomes equal to or greater than the abnormality determination value α [°C] (FIG. 6). On the other hand, in the case where the heater inlet coolant temperature sensor 22 has the stuck abnormality (an abnormality in which the detected value is stuck to a low coolant temperature value), the coolant temperature inlet coolant temperature thw2 (detected value) does not increase although the temperature of the coolant in the heater passageway 202 actually increases, so that the deviation of the heater inlet coolant temperature thw2 does not become equal to or greater than the abnormality determination value α [°C].

[0065] In view of these points, in this example, in the case where the deviation of the heater inlet coolant temperature thw2 detected by the heater inlet coolant temperature sensor 22 when the coolant in the engine coolant passageway 201 (in the engine 1) and the coolant in the heater passageway 202 become sufficiently mixed (the deviation thereof from the detected heater inlet coolant temperature value obtained when the changeover valve is opened (when the engine is started)) is greater than or equal to the abnormality determination value α (e.g., α=5 [°C]) (i.e., the case where thw2 deviation$\geq\alpha$), the ECU 300 determines that the heater inlet coolant temperature sensor 22 is normal. In the case where the deviation of the heater inlet coolant temperature thw2 is smaller than the abnormality determination value α, the ECU 300 determines that the heater inlet coolant temperature sensor 22 has the stuck abnormality.

[0066] As described above, in the abnormality determination process of this example, in the case where it is determined that the heater inlet coolant temperature sensor 22 is not normal by the first normality determination regarding the heater inlet coolant temperature sensor 22 (the case where the heater inlet coolant temperature sensor 22 is abnormal or the exhaust heat recovery device 6 or the EGR cooler 7 has a fault), the changeover valve 10 is opened, so that the high-temperature coolant from the engine 1 is caused to flow into the heater passageway 202 and therefore the temperature of the coolant in the heater passageway 202 increases. During such a state of increased coolant temperature, the second normality determination regarding the heater inlet coolant temperature sensor 22 is performed on the basis of the thw2 deviation (amount of change) of the bypass coolant temperature detected by the heater inlet coolant temperature sensor 22. Therefore, the presence or absence of an abnormality of the heater inlet coolant temperature sensor 22 (a bypass coolant temperature sensor) can be precisely determined without making a false determination, even when the bypass passageway does not have a heat source available due to a fault of the exhaust heat recovery device 6 or the EGR cooler 7, or the like.

[0067] Incidentally, although in the aforementioned example, the process routine shown in FIG. 5 is started at the time point (IG-ON) when the ignition switch is turned on, the process routine shown in FIG. 5 may also be started when there is an engine-starting request in the case where the vehicle equipped with the engine 1 is a hybrid vehicle.

(EXAMPLE 2 OF DETERMINATION PROCESS)

[0068] Although in the example 1 of the determination process, it is determined that the changeover valve 10 has opened, at the time point when a certain time (time time1) elapses following the start of electrification of the electric heater 15 of the changeover valve 10, it is also permissible to estimate the ambient coolant temperature Tvw of the temperature sensitive portion 14 of the changeover valve 10, and determine whether the changeover valve 10 has opened on the basis of the estimated value of the changeover valve's ambient coolant temperature Tvw.

[0069] Concretely, using the engine coolant temperature thw1 detected by the engine coolant temperature sensor 21, the ECU 300 estimates the changeover valve's ambient coolant temperature Tvw on the basis of a map or a calculation expression. At the time point when the estimated value of the changeover valve's ambient coolant temperature Tvw reaches the valve-opening temperature (70°C) of the changeover valve 10, the ECU 300 determines that "the changeover valve 10 has opened". Then, after the aforementioned set time time2 (a time needed before the coolant temperature in the heater passageway 202 sufficiently rises) elapses following the time point when it is determined that the valve 10 has opened, the normality determination regarding the heater inlet coolant temperature sensor 22 is performed (the determination process of step ST110 in FIG. 5 is executed).

[0070] Thus, in the open-valve state determination process of this example, since the presence of an open state of the changeover valve 10 is determined on the basis of the estimated value of the changeover valve's ambient coolant temperature Tvw, the second normality determination regarding the heater inlet coolant temperature sensor 22 can be carried out in a short time, in comparison with the above-described open-valve state determination process of the example 1 of the determination process, that is, in comparison with the case where the presence of an open state of the changeover valve 10 is determined on the basis of the elapsed time following the start of electrification of the electric heater 15.

[0071] That is, in the example 1 of the determination process, in order to prevent a false determination that the changeover valve 10 has opened when the changeover valve 10 actually has not opened, the coolant mixture criterion time is adapted on the basis of the condition in which it takes the longest time before the changeover valve 10 is opened (e.g., a condition in which the engine is idling and the engine is in a low-temperature environment). However, as for such an adaptation, the margin is very large, so that there is inevitably a long time before the second normality determination regarding the heater inlet coolant temperature sensor 22 is performed. However, by adopting a design such that it is determined that the changeover valve 10 has opened when the estimated value of the changeover valve's ambient coolant temperature (=the wax temperature) Tvw reaches the valve-opening temperature (70°C), it becomes possible to determine that the changeover valve 10 has opened according to the actual opening of the changeover valve 10. This eliminates the need to provide the aforementioned margin, so that it becomes possible to shorten the time prior to the normality determination (the second normality determination) regarding the heater inlet coolant temperature sensor 22.

[0072] Incidentally, although in the forgoing example, the detected coolant temperature value detected by the engine coolant temperature sensor 21 is used to estimate the changeover valve's ambient coolant temperature Tvw, an estimated value of the engine coolant temperature thw1 may instead be used to estimate the changeover valve's ambient coolant temperature Tvw. An example of the estimation will be described below.

[0073] Firstly, the ECU 300 calculates a cooling loss Qw in the engine 1 with reference to a map adapted beforehand by experiments, simulations, etc., on the basis of the engine rotation speed Ne and the load factor kl calculated from output signals of an engine rotation speed sensor (not shown). Incidentally, the load factor kl can be calculated, for example, as a value that indicates the proportion of the present load to the maximum engine load, by referring to a map or the like on the basis of the engine rotation speed Ne and the intake air pressure.

[0074] Next, using a calculated cooling loss Qw, the ECU 300 calculates an estimated value of the engine coolant temperature thw1 on the basis of the following expression (1), that is, a Laplace transform expression of the engine coolant temperature thw1. Furthermore, using the calculated estimated value of the engine coolant temperature thw1, the ECU 300 calculates an estimated value of the changeover valve's ambient coolant temperature Tvw from the following expression (2).

$$\mathcal{L}(thw1) = \frac{\frac{L}{\lambda A}}{\left(\frac{CL}{\lambda A}\right)^2 S^2 + \frac{2CL}{\lambda A} S} \mathcal{L}(Qw(kl, Ne)) \qquad \cdots (1)$$

$\mathcal{L}$ (___): Laplace transform
C: heat capacity [J/°C]
λ: heat conductivity between thermal points [W/(m°C)]
L: distance between thermal points [m]
A: heat conduction area between thermal points [m^2]

$$thw1 - Tvw = \frac{\alpha}{\beta s + 1} \qquad \cdots (2)$$

α and β: constants

[0075] Herein, the parameters C, λ, L and A in the foregoing expression (1) are set at values that are adapted on the assumption of a coolant mass around a highest-temperature portion in the coolant jacket of the cylinder head during a stop of the coolant in the engine 1.

[0076] Besides, an estimated value of the changeover valve's ambient coolant temperature Tvw may also be calculated by other techniques. For example, the following calculation technique may be employed. That is, using the engine rotation speed Ne and the load factor kl as parameters, the coolant temperature at the coolant outlet 1b of the engine 1 is acquired through experiments, simulations, etc. On the basis of results of the acquisition, estimated values of the changeover valve's ambient coolant temperature Tvw are adapted and mapped beforehand by experiments, simulations, or the like. Then, by referring to the map on the basis of the actual engine rotation speed Ne and the actual load factor kl, an estimated value of the changeover valve's ambient coolant temperature Tvw is calculated.

[0077] Although in the foregoing embodiments and examples, the changeover valve 10 equipped with the temperature sensitive portion that displaces the valve body is used as a control valve that controls the circulation of the coolant between the engine coolant passageway and the heater passageway (bypass passageway), the invention is not limited so, that is, it is also permissible to use a control valve that is opened and closed by a different type of actuator, for example, a solenoid or the like.

[0078] Although in the foregoing embodiments and examples, the electric coolant pump is used for the circulation of the coolant, the invention is not limited so, that is, it is also permissible to use a mechanical coolant pump for the circulation of the coolant.

[0079] Although in the foregoing embodiments and examples, the invention is applied to a cooling system in which a heater, an exhaust heat recovery device and an EGR cooler are incorporated as heat exchangers, the invention is also applicable to cooling systems in which, in addition to the exhaust heat recovery device and the EGR cooler, heat exchangers, such as an ATF (Automatic Transmission Fluid) warmer, an ATF cooler, etc., are incorporated.
[0080] The invention can be utilized for a coolant temperature sensor abnormality determination apparatus that determines the presence or absence of abnormality of a coolant temperature sensor that detects the coolant temperature of a heater system in a cooling system of an engine (internal combustion engine).

Claims

1. A coolant temperature sensor abnormality determination apparatus which is applied to an engine cooling system that includes a coolant passageway (200) comprising an engine coolant passageway (201) and a bypass passageway (202) that bypasses an engine (1), a control valve (10) that can be in an open state to allow mixing of coolant from the engine coolant passageway (201) and coolant from the bypass passageway (202) at a confluence between the engine coolant passageway (201) and the bypass passageway (202) and that can be in a closed state to restrict the mixing of the coolant from the engine coolant passageway (201) and the coolant from the bypass passageway (202) at the confluence between the engine coolant passageway (201) and the bypass passageway (202), and a bypass coolant temperature sensor (22) that is arranged in the coolant passageway (200), downstream of the confluence between the engine coolant passageway (201) and the bypass passageway (202), and that detects a bypass coolant temperature, and which determines whether the bypass coolant temperature sensor (22) is abnormal, the coolant temperature sensor abnormality determination apparatus being **characterized by** comprising
determination means (300) for opening the control valve (10) if an amount of increase of a detected value of the bypass coolant temperature obtained when the bypass coolant temperature is estimated to be equal to or greater than a first predetermined value is smaller than a second predetermined value, and for determining whether the bypass coolant temperature sensor (22) is abnormal based on an amount of change in the detected value of the bypass coolant temperature obtained after the control valve (10) opens.

2. The coolant temperature sensor abnormality determination apparatus according claim 1, wherein:

   the determination means (300) determines that the bypass coolant temperature sensor (22) is normal, if the amount of increase in the detected value of the bypass coolant temperature becomes equal to or greater than the second predetermined value after the control valve (10) opens; and
   the determination means (300) determines that the bypass coolant temperature sensor (22) is abnormal, if the amount of increase in the detected value of the bypass coolant temperature is smaller than the second predetermined value after the control valve (10) opens.

3. The coolant temperature sensor abnormality determination apparatus according to claim 1 or 2, wherein the bypass passageway (202) is provided with at least one of an exhaust heat recovery device (6) and an EGR cooler (7).

4. The coolant temperature sensor abnormality determination apparatus according to any one of claims 1 to 3, wherein:

   the control valve (10) is a temperature-sensitive operation valve that has a temperature sensitive portion (14) that displaces a valve body (12); and
   the coolant temperature sensor abnormality determination apparatus includes open-valve state determination means for determining that the control valve (10) has opened, when an estimated value of an ambient coolant temperature of the control valve (10) becomes equal to or greater than a valve-opening temperature of the control valve (10).

5. The coolant temperature sensor abnormality determination apparatus according to any one of claims 1 to 4, wherein after a predetermined time elapses following opening of the control valve (10), the determination means (300) executes determination regarding the bypass coolant temperature sensor (22).

6. A coolant temperature sensor abnormality determination method which is for use in an engine cooling system that includes a coolant passageway (200) comprising an engine coolant passageway (201) and a bypass passageway (202) that bypasses an engine (1), a control valve (10) that can be in an open state to allow mixing of coolant from the engine coolant passageway (201) and coolant from the bypass passageway (202) at a confluence between the engine coolant passageway (201) and the bypass passageway (202) and that can be in a closed state to restrict

the mixing of the coolant from the engine coolant passageway (201) and the coolant from the bypass passageway (202) at the confluence between the engine coolant passageway (201) and the bypass passageway (202), and a bypass coolant temperature sensor (22) that is arranged in the coolant passageway (200), downstream of the confluence between the engine coolant passageway (201) and the bypass passageway (202), and that detects a bypass coolant temperature, and which determines whether the bypass coolant temperature sensor (22) is abnormal, the coolant temperature sensor abnormality determination method being **characterized by** comprising:

detecting the bypass coolant temperature by using the bypass coolant temperature sensor (22) when the bypass coolant temperature is estimated to be equal to or greater than a first predetermined value,
determining that the bypass coolant temperature sensor (22) is normal if an amount of increase in the bypass coolant temperature detected is greater than or equal to a second predetermined value; and
opening the control valve (10) if the amount of increase in the bypass coolant temperature detected is smaller than the second predetermined value, and detecting the bypass coolant temperature again by using the bypass coolant temperature sensor (22) after the control valve (10) opens, and determining whether the bypass coolant temperature sensor (22) is abnormal on the basis of an amount of change in the bypass coolant temperature between before and after the control valve (10) opens.

Patentansprüche

1. Kühlmitteltemperatursensor-Abnormalitätsbestimmungsvorrichtung, die in einem Motorkühlsystem verwendet wird, enthaltend: einen Kühlmitteldurchgang (200), der einen Motorkühlmitteldurchgang (201) und einen Umgehungsdurchgang (202), der einen Motor (1) umgeht, umfasst, ein Steuerventil (10), das sich in einem offenen Zustand befinden kann, um ein Mischen von Kühlmittel von dem Motorkühlmitteldurchgang (201) und Kühlmittel von dem Umgehungsdurchgang (202) an einem Zusammenfluss zwischen dem Motorkühlmitteldurchgang (201) und dem Umgehungsdurchgang (202) zu erlauben, und das sich in einem geschlossenen Zustand befinden kann, um das Mischen des Kühlmittels von dem Motorkühlmitteldurchgang (201) und des Kühlmittels von dem Umgehungsdurchgang (202) an dem Zusammenfluss zwischen dem Motorkühlmitteldurchgang (201) und dem Umgehungsdurchgang (202) zu unterbinden, und einen Umgehungskühlmitteltemperatursensor (22), der in dem Kühlmitteldurchgang (200) stromabwärts des Zusammenflusses zwischen dem Motorkühlmitteldurchgang (201) und dem Umgehungsdurchgang (202) angeordnet ist und der eine Umgehungskühlmitteltemperatur detektiert, und bestimmt, ob der Umgehungskühlmitteltemperatursensor (22) abnormal ist, wobei die Kühlmitteltemperatursensor-Abnormalitätsbestimmungsvorrichtung **dadurch gekennzeichnet ist, dass** sie umfasst:

   ein Bestimmungsmittel (300) zum Öffnen des Steuerventils (10), wenn ein Erhöhungsbetrag eines detektierten Wertes der Umgehungskühlmitteltemperatur, der erhalten wird, wenn geschätzt wird, dass die Umgehungskühlmitteltemperatur mindestens so hoch ist wie ein erster zuvor festgelegter Wert, kleiner ist als ein zweiter zuvor festgelegter Wert, und zum Bestimmen - auf der Basis eines Änderungsbetrages des detektierten Wertes der Umgehungskühlmitteltemperatur, der erhalten wird, nachdem sich das Steuerventil (10) geöffnet hat -, ob die Umgehungskühlmitteltemperatursensor (22) abnormal ist.

2. Kühlmitteltemperatursensor-Abnormalitätsbestimmungsvorrichtung nach Anspruch 1, wobei:

   das Bestimmungsmittel (300) bestimmt, dass die Umgehungskühlmitteltemperatursensor (22) normal ist, wenn der Erhöhungsbetrag des detektierten Wertes der Umgehungskühlmitteltemperatur mindestens so groß wird wie der zweite zuvor festgelegte Wert, nachdem sich das Steuerventil (10) geöffnet hat; und
   das Bestimmungsmittel (300) bestimmt, dass die Umgehungskühlmitteltemperatursensor (22) abnormal ist, wenn der Erhöhungsbetrag des detektierten Wertes der Umgehungskühlmitteltemperatur kleiner ist als der zweite zuvor festgelegte Wert, nachdem sich das Steuerventil (10) geöffnet hat.

3. Kühlmitteltemperatursensor-Abnormalitätsbestimmungsvorrichtung nach Anspruch 1 oder 2, wobei der Umgehungsdurchgang (202) mit einer Abgaswärmerückgewinnungsvorrichtung (6) und/oder einem EGR-Kühler (7) versehen ist.

4. Kühlmitteltemperatursensor-Abnormalitätsbestimmungsvorrichtung nach einem der Ansprüche 1 bis 3, wobei:

   das Steuerventil (10) ein temperaturempfindliches Betriebsventil ist, das einen temperaturempfindlichen Abschnitt (14) aufweist, der einen Ventilkörper (12) verdrängt; und die Kühlmitteltemperatursensor-Abnormalitätsbestimmungsvorrichtung ein Offenventilzustandsbestimmungsmittel enthält, um zu bestimmen, dass sich das Steuerventil (10) geöffnet hat, wenn ein geschätzter Wert einer Umgebungskühlmitteltemperatur des Steuerventils (10) mindestens so groß wird wie einen Ventilöffnungstemperatur des Steuerventils (10).

5. Kühlmitteltemperatursensor-Abnormalitätsbestimmungsvorrichtung nach einem der Ansprüche 1 bis 4, wobei, nachdem eine zuvor festgelegte Zeit nach der Öffnung des Steuerventils (10) verstrichen ist, das Bestimmungsmittel (300) eine Bestimmung bezüglich des Umgehungskühlmitteltemperatursensors (22) ausführt.

6. Kühlmitteltemperatursensor-Abnormalitätsbestimmungsverfahren zur Verwendung in einem Motorkühlsystem, enthaltend: einen Kühlmitteldurchgang (200), der einen Motorkühlmitteldurchgang (201) und einen Umgehungsdurchgang (202), der einen Motor (1) umgeht, umfasst, ein Steuerventil (10), das sich in einem offenen Zustand befinden kann, um ein Mischen von Kühlmittel von dem Motorkühlmitteldurchgang (201) und Kühlmittel von dem Umgehungsdurchgang (202) an einem Zusammenfluss zwischen dem Motorkühlmitteldurchgang (201) und dem Umgehungsdurchgang (202) zu erlauben, und das sich in einem geschlossenen Zustand befinden kann, um das Mischen des Kühlmittels von dem Motorkühlmitteldurchgang (201) und des Kühlmittels von dem Umgehungsdurchgang (202) an dem Zusammenfluss zwischen dem Motorkühlmitteldurchgang (201) und dem Umgehungsdurchgang (202) zu unterbinden, und einen Umgehungskühlmitteltemperatursensor (22), der in dem Kühlmitteldurchgang (200) stromabwärts des Zusammenflusses zwischen dem Motorkühlmitteldurchgang (201) und dem Umgehungsdurchgang (202) angeordnet ist und der eine Umgehungskühlmitteltemperatur detektiert, und bestimmt, ob der Umgehungskühlmitteltemperatursensor (22) abnormal ist, wobei das Kühlmitteltemperatursensor-Abnormalitätsbestimmungsverfahren **dadurch gekennzeichnet ist, dass** es umfasst:

Detektieren der Umgehungskühlmitteltemperatur unter Verwendung des Umgehungskühlmitteltemperatursensors (22), wenn geschätzt wird, dass die Umgehungskühlmitteltemperatur mindestens so groß ist wie ein erster zuvor festgelegter Wert,
Bestimmen, dass die Umgehungskühlmitteltemperatursensor (22) normal ist, wenn ein Erhöhungsbetrag der detektierten Umgehungskühlmitteltemperatur mindestens so groß ist wie ein zweiter zuvor festgelegter Wert, und
Öffnen des Steuerventils (10), wenn der Erhöhungsbetrag der detektierten Umgehungskühlmitteltemperatur kleiner als der zweite zuvor festgelegte Wert ist, und erneutes Detektieren der Umgehungskühlmitteltemperatur unter Verwendung des Umgehungskühlmitteltemperatursensors (22), nachdem sich das Steuerventil (10) geöffnet hat, und Bestimmen - auf der Basis eines Änderungsbetrages der Umgehungskühlmitteltemperatur zwischen, bevor und nachdem sich das Steuerventil (10) geöffnet hat -, ob der Umgehungskühlmitteltemperatursensor (22) abnormal ist.

Revendications

1. Appareil de détermination d'anomalie de capteur de température d'agent de refroidissement qui est appliqué à un système de refroidissement de moteur qui comprend un passage d'agent de refroidissement (200) comportant un passage d'agent de refroidissement de moteur (201) et un passage de dérivation (202) qui contourne un moteur (1), une soupape de commande (10) qui peut être dans un état ouvert pour permettre un mélange d'agent de refroidissement provenant du passage d'agent de refroidissement de moteur (201) et d'agent de refroidissement provenant du passage de dérivation (202) à un confluent entre le passage d'agent de refroidissement de moteur (201) et le passage de dérivation (202) et qui peut être dans un état fermé pour limiter le mélange de l'agent de refroidissement provenant du passage d'agent de refroidissement de moteur (201) et de l'agent de refroidissement provenant du passage de dérivation (202) au confluent entre le passage d'agent de refroidissement de moteur (201) et le passage de dérivation (202), et un capteur de température d'agent de refroidissement de dérivation (22) qui est disposé dans le passage d'agent de refroidissement (200), en aval du confluent entre le passage d'agent de refroidissement de moteur (201) et le passage de dérivation (202), et qui détecte une température d'agent de refroidissement de dérivation, et qui détermine si le capteur de température d'agent de refroidissement de dérivation (22) est anormal, l'appareil de détermination d'anomalie de capteur de température d'agent de refroidissement étant **caractérisé en ce qu'**il comporte
des moyens de détermination (300) destinés à ouvrir la soupape de commande (10) si une quantité d'augmentation d'une valeur détectée de la température d'agent de refroidissement de dérivation obtenue quand la température d'agent de refroidissement de dérivation est égale ou supérieure à une première valeur prédéterminée est plus petite qu'une deuxième valeur prédéterminée, et destinés à déterminer si le capteur de température d'agent de

refroidissement de dérivation (22) est anormal sur la base d'une quantité de changement de la valeur détectée de la température d'agent de refroidissement de dérivation obtenue après que la soupape de commande (10) s'ouvre.

2. Appareil de détermination d'anomalie de capteur de température d'agent de refroidissement selon la revendication 1, dans lequel :

les moyens de détermination (300) déterminent que le capteur de température d'agent de refroidissement de dérivation (22) est normal, si la quantité d'augmentation de la valeur détectée de la température d'agent de refroidissement de dérivation devient égale ou supérieure à la deuxième valeur prédéterminée après que la soupape de commande (10) s'ouvre ; et
les moyens de détermination (300) déterminent que le capteur de température d'agent de refroidissement de dérivation (22) est anormal, si la quantité d'augmentation de la valeur détectée de la température d'agent de refroidissement de dérivation est plus petite que la deuxième valeur prédéterminée après que la soupape de commande (10) s'ouvre.

3. Appareil de détermination d'anomalie de capteur de température d'agent de refroidissement selon la revendication 1 ou 2, dans lequel le passage de dérivation (202) est pourvu d'au moins un d'un dispositif de récupération de chaleur d'échappement (6) et d'un dispositif de refroidissement de recyclage de gaz d'échappement (7).

4. Appareil de détermination d'anomalie de capteur de température d'agent de refroidissement selon l'une quelconque des revendications 1 à 3, dans lequel :

la soupape de commande (10) est une soupape de fonctionnement thermosensible qui a une partie thermosensible (14) qui déplace un corps de soupape (12) ; et
l'appareil de détermination d'anomalie de capteur de température d'agent de refroidissement comprend des moyens de détermination d'état ouvert de soupape destinés à déterminer que la soupape de commande (10) s'est ouverte, quand une valeur estimée d'une température ambiante d'agent de refroidissement de la soupape de commande (10) devient égale ou supérieure à une température d'ouverture de soupape de la soupape de commande (10).

5. Appareil de détermination d'anomalie de capteur de température d'agent de refroidissement selon l'une quelconque des revendications 1 à 4, dans lequel, après écoulement d'un temps prédéterminé à la suite de l'ouverture de la soupape de commande (10), les moyens de détermination (300) exécutent une détermination concernant le capteur de température d'agent de refroidissement de dérivation (22).

6. Procédé de détermination d'anomalie de capteur de température d'agent de refroidissement qui est destiné à une utilisation dans un système de refroidissement de moteur qui comprend un passage d'agent de refroidissement (200) comportant un passage d'agent de refroidissement de moteur (201) et un passage de dérivation (202) qui contourne un moteur (1), une soupape de commande (10) qui peut être dans un état ouvert pour permettre un mélange d'agent de refroidissement provenant du passage d'agent de refroidissement de moteur (201) et d'agent de refroidissement provenant du passage de dérivation (202) à un confluent entre le passage d'agent de refroidissement de moteur (201) et le passage de dérivation (202) et qui peut être dans un état fermé pour limiter le mélange de l'agent de refroidissement provenant du passage d'agent de refroidissement de moteur (201) et de l'agent de refroidissement provenant du passage de dérivation (202) au confluent entre le passage d'agent de refroidissement de moteur (201) et le passage de dérivation (202), et un capteur de température d'agent de refroidissement de dérivation (22) qui est disposé dans le passage d'agent de refroidissement (200), en aval du confluent entre le passage d'agent de refroidissement de moteur (201) et le passage de dérivation (202), et qui détecte une température d'agent de refroidissement de dérivation, et qui détermine si le capteur de température d'agent de refroidissement de dérivation (22) est anormal, le procédé de détermination d'anomalie de capteur de température d'agent de refroidissement étant **caractérisé en ce qu'**il comporte le fait de :

détecter la température d'agent de refroidissement de dérivation en utilisant le capteur de température d'agent de refroidissement de dérivation (22) quand la température d'agent de refroidissement de dérivation est estimée être égale ou supérieure à une première valeur prédéterminée,
déterminer que le capteur de température d'agent de refroidissement de dérivation (22) est normal si une quantité d'augmentation de la température d'agent de refroidissement de dérivation détectée est supérieure ou égale à une deuxième valeur prédéterminée ; et
ouvrir la soupape de commande (10) si la quantité d'augmentation de la température d'agent de refroidissement

de dérivation détectée est plus petite que la deuxième valeur prédéterminée, et détecter de nouveau la température d'agent de refroidissement de dérivation en utilisant le capteur de température d'agent de refroidissement de dérivation (22) après que la soupape de commande (10) s'ouvre, et déterminer si le capteur de température d'agent de refroidissement de dérivation (22) est anormal sur la base d'une quantité de changement de la température d'agent de refroidissement de dérivation entre avant et après que la soupape de commande (10) s'ouvre.

FIG. 1

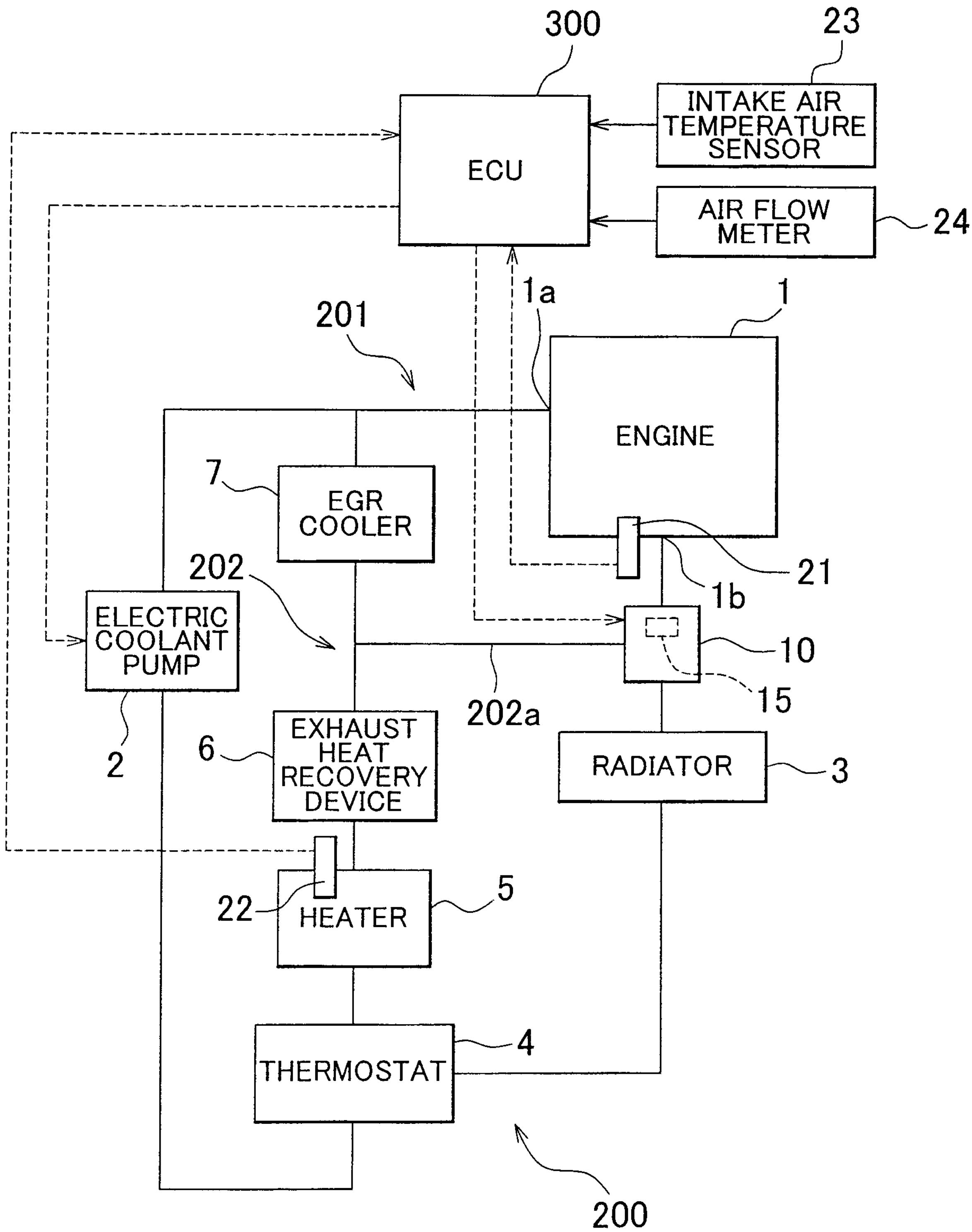

300
23
ECU
INTAKE AIR TEMPERATURE SENSOR
AIR FLOW METER
24
1a
1
201
ENGINE
7
EGR COOLER
202
21
1b
ELECTRIC COOLANT PUMP
10
15
202a
EXHAUST HEAT RECOVERY DEVICE
6
2
RADIATOR
3
22
HEATER
5
THERMOSTAT
4
200

FIG. 2A

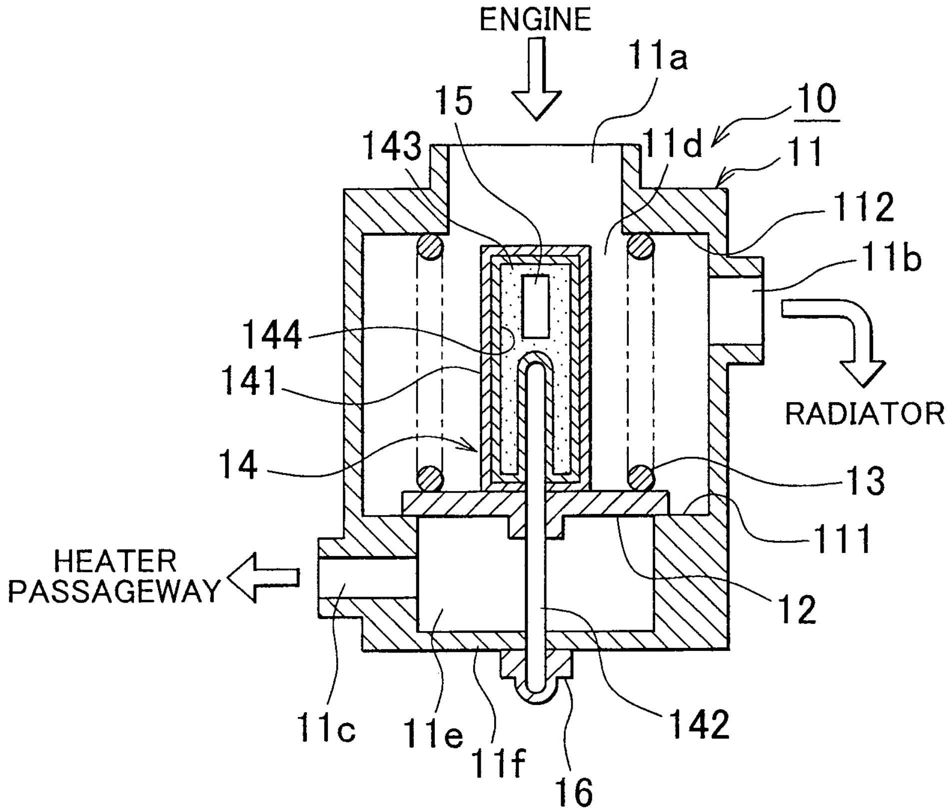

ENGINE
11a
15
10
143
11d
11
112
11b
144
141
RADIATOR
14
13
111
HEATER PASSAGEWAY
12
142
11c
11e
11f
16

FIG. 2B

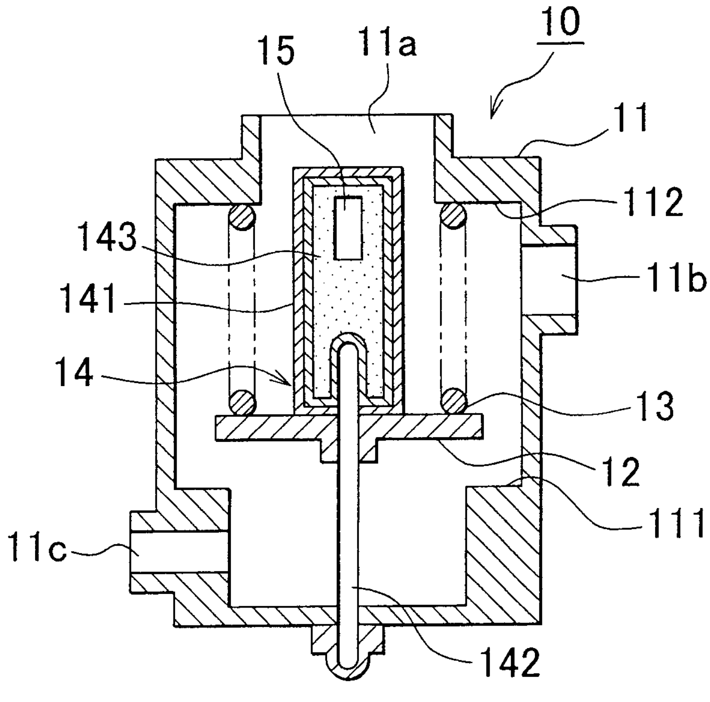

15
11a
10
11
112
143
11b
141
14
13
12
111
11c
142

FIG. 3A

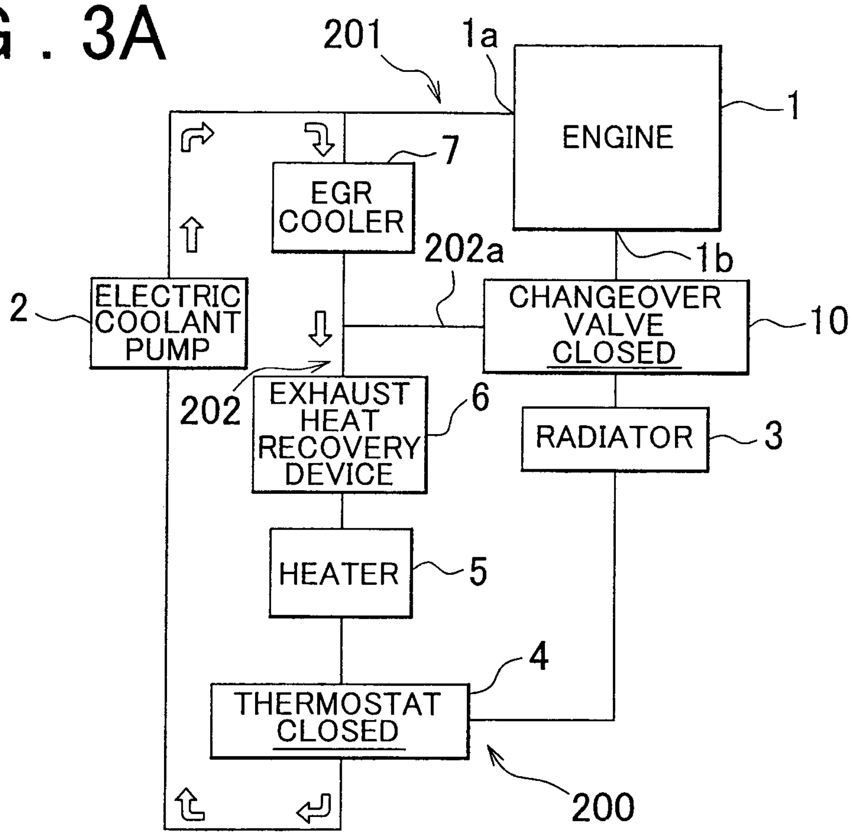

201
1a
ENGINE
1
7
EGR COOLER
202a
1b
2
ELECTRIC COOLANT PUMP
CHANGEOVER VALVE CLOSED
10
202
EXHAUST HEAT RECOVERY DEVICE
6
RADIATOR
3
HEATER
5
4
THERMOSTAT CLOSED
200

FIG. 3B

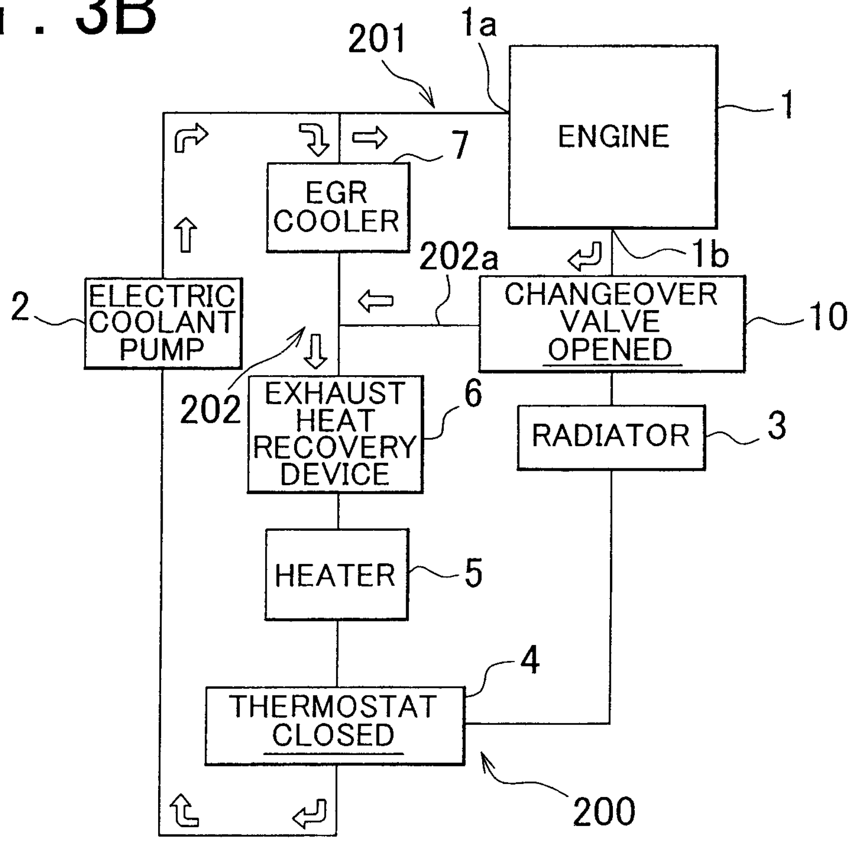

201
1a
ENGINE
1
7
EGR COOLER
202a
1b
2
ELECTRIC COOLANT PUMP
CHANGEOVER VALVE OPENED
10
202
EXHAUST HEAT RECOVERY DEVICE
6
RADIATOR
3
HEATER
5
4
THERMOSTAT CLOSED
200

FIG. 4

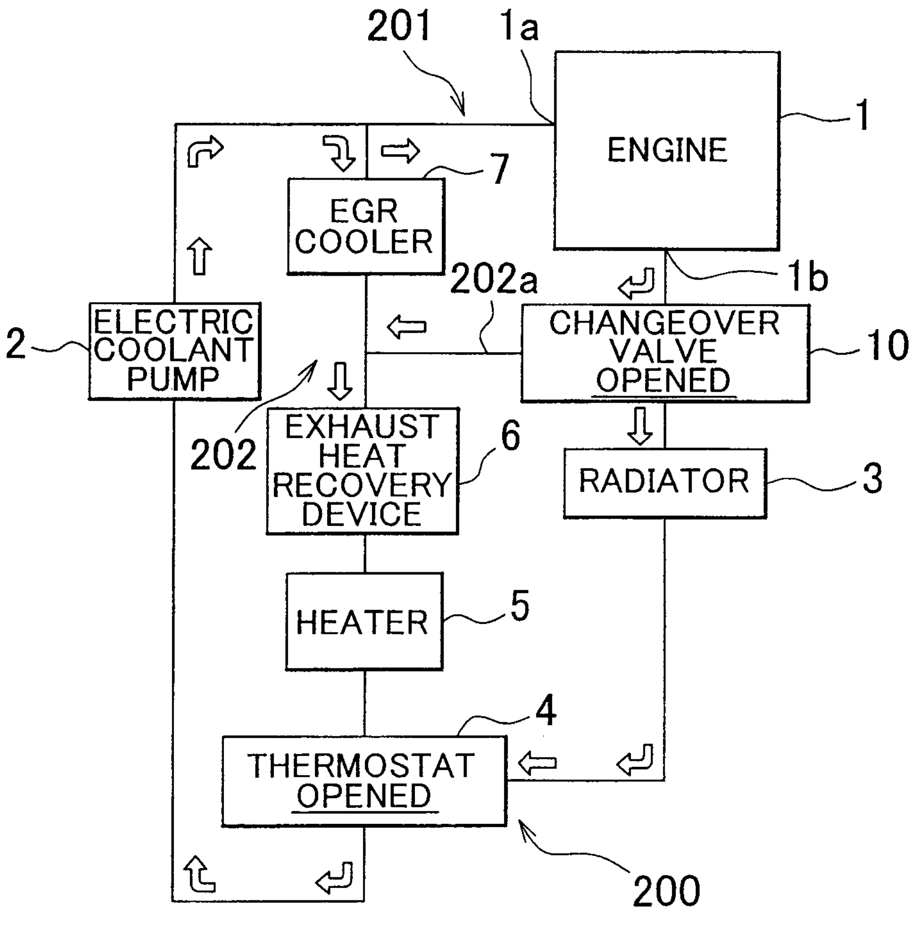
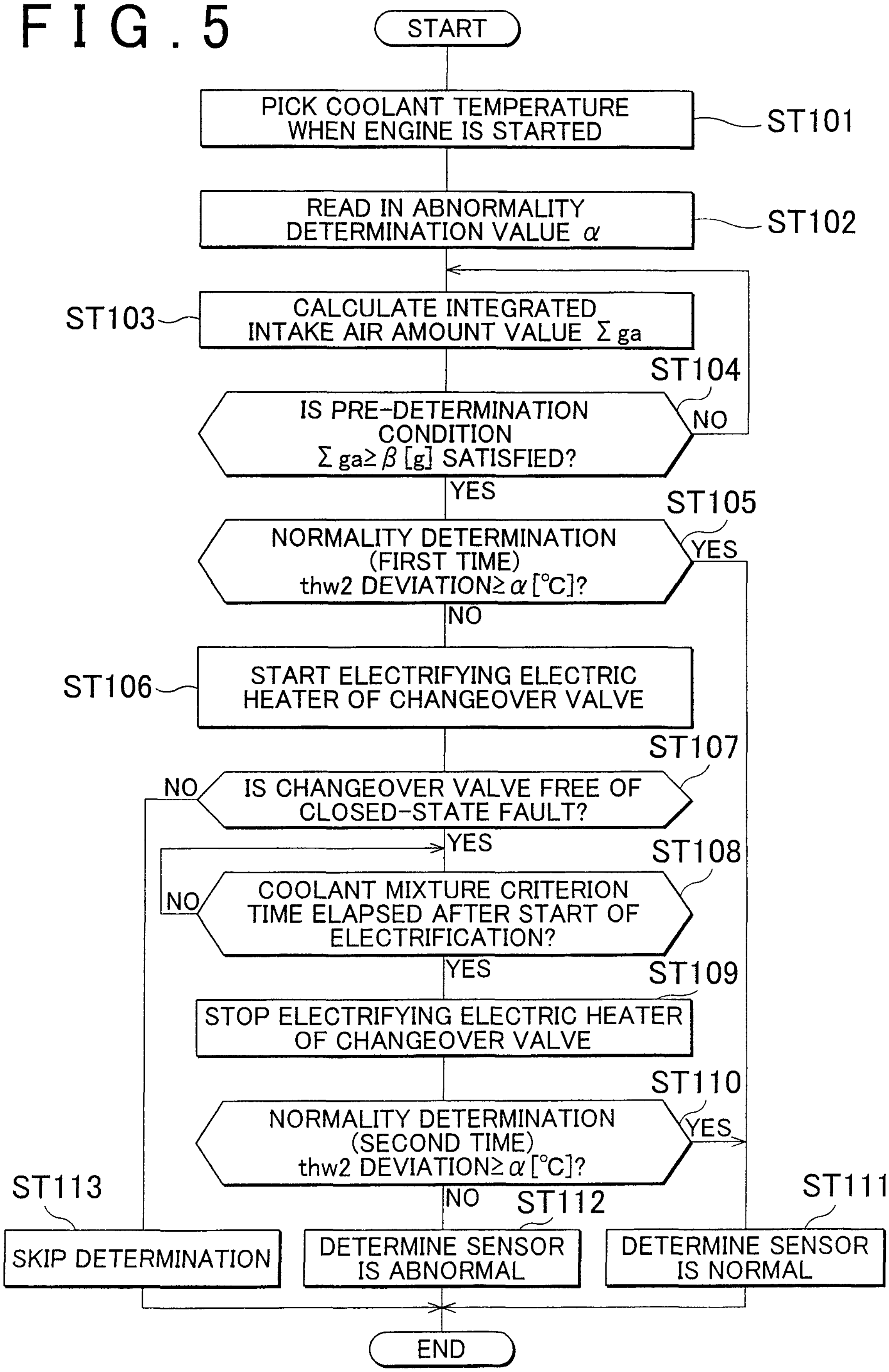
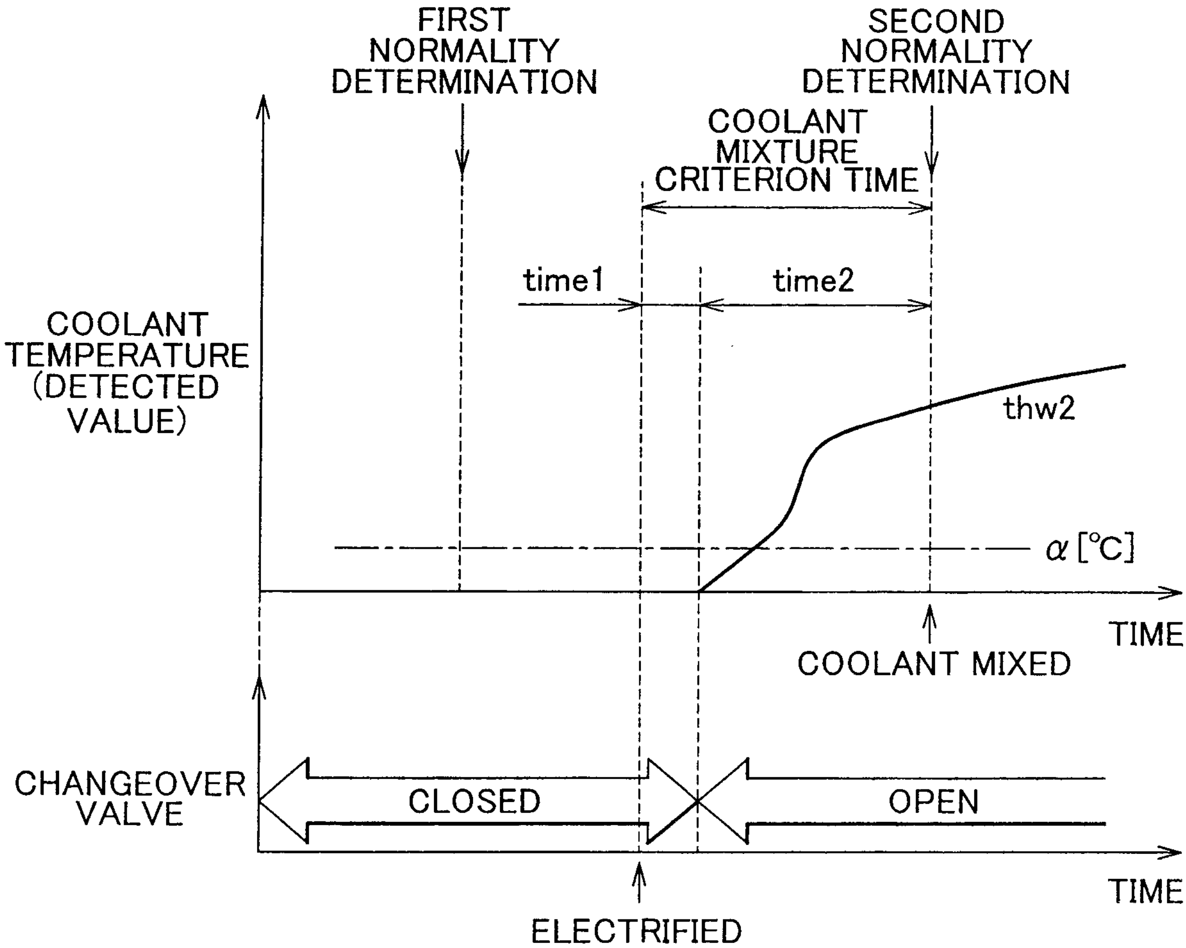

201
1a
ENGINE
1
7
EGR COOLER
202a
1b
2
ELECTRIC COOLANT PUMP
CHANGEOVER VALVE OPENED
10
202
EXHAUST HEAT RECOVERY DEVICE
6
RADIATOR
3
HEATER
5
4
THERMOSTAT OPENED
200

FIG. 5


START
PICK COOLANT TEMPERATURE WHEN ENGINE IS STARTED
ST101
READ IN ABNORMALITY DETERMINATION VALUE α
ST102
ST103
CALCULATE INTEGRATED INTAKE AIR AMOUNT VALUE Σ ga
ST104
IS PRE-DETERMINATION CONDITION Σ ga≥β [g] SATISFIED?
NO
YES
ST105
NORMALITY DETERMINATION (FIRST TIME) thw2 DEVIATION≥α [°C]?
YES
NO
ST106
START ELECTRIFYING ELECTRIC HEATER OF CHANGEOVER VALVE
ST107
IS CHANGEOVER VALVE FREE OF CLOSED-STATE FAULT?
NO
YES
ST108
COOLANT MIXTURE CRITERION TIME ELAPSED AFTER START OF ELECTRIFICATION?
NO
YES
ST109
STOP ELECTRIFYING ELECTRIC HEATER OF CHANGEOVER VALVE
ST110
NORMALITY DETERMINATION (SECOND TIME) thw2 DEVIATION≥α [°C]?
YES
NO
ST113
SKIP DETERMINATION
ST112
DETERMINE SENSOR IS ABNORMAL
ST111
DETERMINE SENSOR IS NORMAL
END

F I G . 6


FIRST
NORMALITY
DETERMINATION
SECOND
NORMALITY
DETERMINATION
COOLANT
MIXTURE
CRITERION TIME
time1
time2
COOLANT
TEMPERATURE
(DETECTED
VALUE)
thw2
α [°C]
TIME
COOLANT MIXED
CHANGEOVER
VALVE
CLOSED
OPEN
TIME
ELECTRIFIED

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2009150266 A **[0002]**
- JP 10073047 A **[0003]**